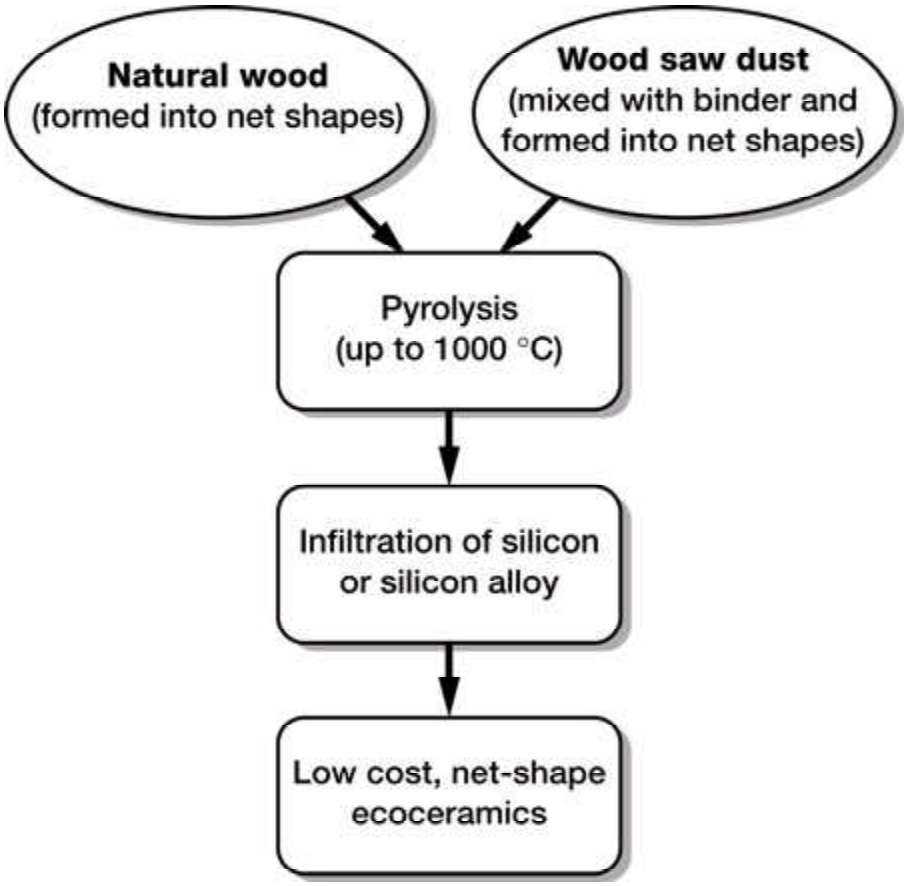
Environment-Conscious Ceramics (Ecoceramics) Technology Received 2001 R&D 100 Award

Since the dawn of human civilization, there has been a delicate balance between the use of resources as human frontiers expanded and the need to have a minimum influence on the ecosystem. The first 200 years of the industrial revolution essentially solved the problem of production. However, the massive production of goods also generated tremendous amounts of byproducts and wastes. In the new millennium, to sustain a healthy life in harmony with nature, it will be extremely important for us to develop various materials, products, and processes that minimize any harmful influence on the environment.

Environment-conscious ceramics (ecoceramics) are a new class of materials that can be fabricated with renewable resources (wood) and wood waste material (wood sawdust). Wood is a "lignocellulosic" material formed by the photosynthetic reaction within the needles or leaves of trees. The photosynthesis process uses sunlight to take carbon dioxide from air and convert it into oxygen and organic materials. Wood has been known to be one of the best and most intricate engineering materials created by nature and known to mankind. In addition, natural woods of various types are available throughout the world. On the other hand, wood sawdusts are generated in abundant quantities by sawmills. Environment-conscious ceramic materials, fabricated via the pyrolysis and infiltration of natural wood-derived preforms, have tailorable properties with numerous potential applications. The experimental studies conducted to date on the development of materials based on biologically derived structures indicate that these materials behave like ceramic materials manufactured by conventional approaches. These structures have been shown to be quite useful in producing porous or dense materials having various microstructures and compositions.



Ecoceramics technology.

A schematic of ecoceramics technology is given in the preceding figure. The wood pieces were dried in an oven and pyrolyzed in a furnace up to 1000 °C in a flowing-argon atmosphere to create carbonaceous preforms. The weight and dimensional changes were recorded after pyrolysis. The pyrolyzed preforms were infiltrated with silicon in a graphite element furnace under vacuum. The infiltration time and temperature depend on the melting point of the infiltrants and the dimensions and properties of the preforms. For silicon infiltration, porous preforms were infiltrated at 1450 °C for 30 min. A wide variety of wood specimens (softwood and hardwood) and wood sawdusts were used to fabricate the carbonaceous preforms. Ecoceramic technology has been used to fabricate parts with complex shapes from the machined wood or carbon specimens shown in the photograph. Detailed thermomechanical characterization of a wide variety of silicon-carbide-based ecoceramics is underway.

Complex-shaped ecoceramic components.

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Special recognition: 2001 R&D 100 Award